7 GREENHOUSE GAS MANAGEMENT

7.1 Introduction

Greenhouse Gas (GHG) Management is included in the EIS/Application because the Project will generate GHG emissions. The content and material included in this section follow the guidelines of the Canadian Environmental Assessment Agency (CEAA) method for incorporating GHG considerations in environmental assessments (CEAA 2003) and global best practices for calculating GHG emissions. Discharges of project GHG emissions are quantified in the context of an industry profile and existing British Columbia (BC) and Canada GHG reduction targets.

The potential effects of the environment on the Project are assessed separately in Section 23. Assumptions used to estimate GHG emissions are described in the Air Quality TDR (Appendix C).

7.2 Scope of Assessment

Based on the CEAA method for incorporating GHG considerations in environmental assessments, "the environmental assessment process cannot consider the bulk of GHG emitted from already existing developments. Furthermore, unlike most project-related environmental effects, the contribution of an individual project to climate change cannot be measured" (CEAA 2003). A measurement of significance of a project potential effect on climate change cannot be assessed quantitatively. Concurrent with CEAA guidance, this GHG management assessment provides a review of the current and anticipated policy and regulatory environments, applicable baseline conditions, industry profile, and a summary of the proposed project GHG emissions during construction and normal operations (at full build out of 19.2 MTPA). The assessment also includes an estimate of GHG emissions resulting from deforestation activities. The Project's estimated annual GHG emissions are compared against the established industry profile as well as current BC and Canada GHG emission levels and reduction targets.

GHG management options available to the Project are described. PNW LNG recognizes that future design or operations modifications may be required to incorporate new GHG management techniques.

7.2.1 Regulatory and Policy Setting

Both BC and Canada have indicated a desire to address the concerns for increased GHG emissions and have created strategic-level plans; however, specific policies are yet to be implemented. Numerous policies, legislation and initiatives are being developed, but there is considerable regulatory uncertainty on how proposed GHG legislation and policy will apply during project operation.

The section presents the prevailing scientific theory on the complex relationship between GHG atmospheric concentrations and climate change. The assessment also discusses regulation and management of GHG emissions through existing guidelines, policy and regulations applicable to the Project.

7.2.1.1 Climate Change and Policy Development

Climate change is a global issue involving complex environmental, energy, economic and political challenges. The science of climate change has not been advanced to the point where a clear cause-and-effect relationship can be established between project-specific or even provincial and national emissions and subtle changes to global climate. However, the incremental increases in global emissions of GHGs from anthropogenic sources over the past 100 years very likely contribute to global climate change (IPCC 2013).

GHGs are released to the atmosphere from a number of natural and anthropogenic sources. Anthropogenic GHG emissions are reported annually by varying levels of government and emission trends are actively discussed at the provincial, national and global levels. GHG emissions from natural sources generally exhibit little annual variation, and have been generally considered as nominal in comparison to fossil fuel emissions.

Climate changes can be attributed to various causes, the primary factors are:

- **Variations in the earth's orbital characteristics**—Computer models and historical evidence suggest that changes in Earth's orbital cycles produce climate changes over long cycles (tens of thousands of years).
- **Volcanic eruptions**—Climatologists have established a link between large volcanic eruptions and short-term, but likely reversible, climate changes.
- **Variations in solar output**—Changes in the solar energy output can lead to climate changes, as the sun is the fundamental source of energy that drives Earth's climate system. Many of the solar energy output changes are cyclic and poorly understood.
- **Increase in GHG concentrations**—Climate models that include the above drivers of climate change cannot fully reproduce the observed temperature trend on Earth (over the past century or more) without including the effects of the increased concentrations of GHGs at the lower levels of Earth's atmosphere generally attributed to anthropogenic sources such as the burning of fossil fuels.

Since climate change is a complex global phenomenon, quantifying potential effects of discrete GHG emissions (e.g., individual projects) to climate trends is discouraged (CEAA 2003). Unlike other VCs in this EA/Application, the contribution of an individual project to climate change cannot be measured. Instead, environmental importance of a specific project should be assessed in the context of applicable policies and regulations. This approach provides the decision makers with the ability to place the predicted increases in GHG emissions within a regional context. Existing GHG policies and applicable regulatory drivers are discussed below.

7.2.1.2 International Regulation and Policy

The Kyoto Protocol was the first international scheme focused on regulating GHG cap-and-trade. It was adapted in 1997 with the purpose of defining measurable and binding emission reduction targets for Annex I countries. Under this protocol Annex I countries are committed to reducing their collective GHG emissions by 5.2% (based on 1990 levels). The commitment period extended from 2008 to 2012 for countries that ratified the protocol, including Canada. Countries that could not reduce their emissions were required to purchase credits from member nations.

In late 2011, Canada exercised its legal right to withdraw from the Kyoto Protocol. To fulfill its obligations under the Protocol, Canada would have had to purchase a significant and costly amount of credits to meet the established reduction requirement. Canada expressed concern that the United States (US) will never ratify the Kyoto Protocol and, thus, any conflicting climate-related legislation with the US had the potential to trigger trade imbalances and penalties.

Although Canada withdrew from Protocol, it remains a part of the United Nations Framework Convention on Climate Change (UNFCCC) process for negotiating the next implementation period (post-2020). At present, Kyoto members are negotiating the Durban Platform for Enhanced Action, which is a new climate deal covering all major emitters; it is to be ratified by 2015 and is to take effect in 2020. The results of the past Doha UNFCCC talks extend the Kyoto Protocol to 2020, although it covers an increasingly smaller set of countries because some countries (e.g., Russia, Japan and Canada) have dropped out.

7.2.1.3 National Regulation and Policy

Canada's national government recognizes that climate change is a global issue requiring a global solution and has set a target of reducing Canada's total GHG emissions by 17% from 2005 levels by 2020 (EC 2010); this is a voluntary commitment and is partially based on Canada's close economic relationship with the US. The target was announced in early 2010 following Canada's withdraw from the Kyoto Protocol (2011). To demonstrate its efforts in reducing GHG reductions, Canada currently reports national GHG emissions annually to the UNFCC.

Canada's Turning the Corner Plan (EC 2007), outlined an action plan for the regulation of GHGs and other air emissions. The plan defined a 2010 implementation date for GHG emission-intensity reduction targets. If implemented, this plan would set an 18% emission-intensity based reduction target (below 2006 levels) with an annual 2% continuous reduction target for every year post 2010. A minimum inclusion threshold for oil and gas facilities was proposed at 3,000 tonnes per facility and 10,000 barrels of oil equivalent per day, per company.

To meet its national GHG reduction target, Canada has updated regulations under the Canadian *Environmental Protection Act* (CEPA 2003) and has begun to implement a sector-by-sector approach to GHG regulation. Under the Section 46 of CEPA, the national government recently added carbon dioxide (CO_2), methane (CH_4) and other GHGs to Schedule 1 of CEPA, thus laying the groundwork for regulation of those substances under that Act. The reporting requirements for 2013 were published in the Canada Gazette on November 2, 2013, and are similarly published every year.

Canada also announced GHG regulations in three sectors—light-duty vehicles, coal-fired electricity generation and heavy-duty vehicles—and plans to announce draft regulations for the oil and gas industry by the end of 2014 (in the form of a gazette for public consultation). Regulation of GHG emissions from the oil and gas sector will be similar in structure to those already released, and is expected to include:

- A performance or intensity-based emission baseline and reduction standard
- Compliance flexibility through credit and offset transfers both within and between regulated entities
- A carbon price ceiling in the form of a technology fund where entities meet compliance requirements by paying into the fund on a fixed dollar per tonne basis.

Development of robust national policies and initiatives requires cooperation with provincial and territorial governments and other partners. However, existing approaches vary greatly between the provinces and territories (as well as with US states). For example, Quebec (and California) is participating in the Western Climate Initiative (WCI), which aims to create a common carbon market; whereas, Alberta's *Specified Gas Emitters Regulation* (SGER) operates independently of any other province or state. By virtue of the close economic relationship with the US, Canadian GHG regulations will need to evaluate alignment with applicable US regulations.

At present, with respect to GHG emissions reporting, Environment Canada (EC) requires any facility emitting more than the 50,000 tonnes of carbon dioxide equivalents per year (t CO_{2e}/y, see Section 7.2.4 for complete definition) to report their annual GHG emissions online.

7.2.1.4 BC Regulation and Policy

In 2007, BC legislated a provincial GHG reduction target of 33% below 2007 emission levels by 2020 and authorized hard limits ("caps") on GHG emissions through the *Greenhouse Gas Reduction (Cap and Trade) Act* (Government of British Columbia 2008b). The legislation also prescribed further provincial targets for 2050 (reduction of 80% below the 2007 levels).

In response to this legislation, the Natural Gas Climate Action Working Group was established in 2008 to develop strategies to reduce GHG emissions. The group includes representatives from the BC Climate Action Secretariat, Ministry of Environment (MOE), Ministry of Energy and Mines, and the oil and gas industry. A Ministerial Order issued on November 25, 2008 required interim targets be established for 2012 and 2016. These interim targets were set at 6% below 2007 levels by 2012 and 18% by 2016.

To achieve these goals, BC has designed and, in some cases, implemented a suite of policy measures to reduce emissions:

- A provincial carbon tax, which was introduced in 2008 through the *Carbon Tax Act* (Government of British Columbia 2008c)
- A carbon neutrality mandate for all public sector operations (Carbon Neutral Government Regulation), which is largely achieved through the sourcing of BC-based offsets via the Climate Action Secretariat (CAS) (Emissions Offset Regulation)
- A mandatory GHG reporting program (Reporting Regulation)
- A potential cap and trade and compliance offset scheme.

In addition, the Oil and Gas Commission (OGC) released venting and flaring requirements under the *Oil and Gas Activities Act* (*OGAA)* (2008d)*,* and GHG reduction targets are outlined in the *Clean Energy Act* as part of BC's energy objectives.

BC's range of climate chance policies was originally intended to meet 73% of its 2020 reduction target. When setting this target, BC did not take into account the potential scale of the shale gas resource in northeast BC, which was in its infancy stage at the time of policy development, nor did it account for the number of LNG export facilities that are being proposed on the west coast. These developments could reduce the likelihood of attaining the original 2020 reduction target, depending on the range of measures taken in this and other sectors.

GHG Reporting/Cap and Trade Scheme

BC has passed legislation that targets reduction in GHG emissions. The Climate Action Plan focuses on seven key sectors including transportation, buildings, waste, agriculture, industry, energy and forestry. Of particular relevance is Bill 18—*The Greenhouse Gas Reduction (Cap-and-Trade) Act* that authorizes a hard cap on GHG emissions in BC—and BC Reg. 393/2008, *The Emission Offsets Regulation* (Government of BC 2009) which defines the requirements for carbon offsets in BC. To date, the requirement for offsets is mandated for all public sector operations. Private sector offset requirements do not exist in BC. Deliberations on the exact carbon framework for BC are currently ongoing.

Enacted in 2010, Bill 18 applies to facilities that emit 10,000 t CO_{2e}/y or more. Those emitting above 25,000 t CO_{2e}/y are required to have their emissions report verified by a third party auditor. Facilities with emissions between 10,000 and 25,000 t CO_{2e}/y are only required to report their emissions. On March 31 of each year, the affected facilities must submit a GHG emissions report.

BC had originally intended on harmonizing Bill 18 with the WCI program, but has not formally committed to a GHG emissions cap and trade system. The WCI initiative commits signatory provinces and states to develop regional targets for reducing GHG emissions, to participate in a GHG registry to track emissions, and to develop a market-based compliance mechanism to meet targets. Currently, the only active members in the WCI are Québec and California. At present, there is regulatory uncertainty as to whether BC will continue with its original plans to join the WCI cap and trade system under the *Greenhouse Gas Reduction (p-and-Trade) Act* or to pursue other avenues of GHG management.

Carbon Neutral Government

The *BC Emission Offsets Regulation* (BC EOR), developed under *The Greenhouse Gas Reduction Targets Act* (GGRTA) defines the requirements for carbon offsets in BC. The regulation establishes rules and requirements for developing and recognizing carbon offsets generated within BC. Operating within the BC EOR is the BC Climate Action Secretariat (CAS) who sets the rules for the BC carbon market. CAS is responsible for purchasing an adequate amount of BC-based carbon offsets to meet a legislated requirement for BC to be carbon neutral.

Carbon offsetting attempts to counteract the tonnes of GHGs produced by an activity by funding various emissions reduction projects elsewhere (e.g., forestry, solar power, wind power, hydroelectricity, micro-hydro, biomass facilities and biofuels). Further, carbon offsets may have additional benefits that occur outside of an emissions trading system and expand past the actual emission reductions or removals, such as technology transfer, ecosystem services or community benefits.

Motor Fuel Tax

Motor fuel tax applies to fuels sold for use or used in internal combustion engines, including industrial equipment (e.g., bulldozers, skidders, chain saws and generators). If a fuel is used to generate power in internal combustion engines, the fuel is subject to both motor fuel tax and carbon tax. In addition, the *Motor Fuel Tax Act* applies to natural gas used or purchased for use in a stationary internal combustion engine that compresses natural gas.

For LNG facilities, different tax rates apply, depending on the location of the natural gas compressor. As the project compressors are located within the facility, and will be used to compress marketable gas, the tax is equal to $1.10 on every 810.3 litres. A higher tax would be applied to natural gas ($1.90 on every 810.3 litres) if a compressor were located outside the processing plant and moved marketable gas from the facility to market, or were outside a storage facility. The Project is not subject to exemptions under the motor fuel tax. These exemptions apply if fuel is used in compressors that transmit waste gas within a gas processing plant or between a gas plant and a well site.

Carbon Tax

The BC carbon tax was implemented on July 1, 2008. It is a broad-based revenue-neutral tax that applies to the purchase or use of fuels such as gasoline, diesel, natural gas, heating fuel, propane, and coal. The carbon tax also applies to combustibles, such as peat and tires, when used to produce energy or heat. Although this carbon tax covers fuel use and purchases, it does not cover industrial process emissions, venting, or fugitive emissions. Consumers pay carbon tax on the GHG emissions from burning natural gas. The tax is revenue-neutral in that every dollar generated by the tax is returned to BC residents through reductions in other taxes (income tax credits, reduced business taxes, etc.).

The carbon tax is a separate fuel tax. The tax rate for a type of fuel is the same throughout BC, regardless of where it is purchased or how it is used. The applicable carbon tax levy began at $10CAD/tonne CO_{2e} in 2008 and has increased by $5 per year. The last increase was July 1, 2012, which stabilized the tax at $30/tonne, amounting to 6.67¢ per litre of fuel and 5.70¢ per cubic metre of natural gas.

The carbon tax rate for natural gas is based on CO_{2e} emissions generated by combustion and has historically been adjusted to account for naturally occurring CO_2 (formation CO_2) in a typical natural gas stream. When natural gas is flared or incinerated at a wellhead or in a processing facility, the facility must self-assess and remit carbon tax on the total volume of natural gas, including the acid gas that is contained in the natural gas.

Acid gas is typically removed during the processing of natural gas and is disposed using several methods, including incineration. Its primary composition is CO_2 and hydrogen sulphide. Under these circumstances, CO_2 vented during the process is not subject to carbon tax. However, any fuel that is used to lift, or assist, in the combustion of acid gas is subject to carbon tax.

Flaring and Venting Reduction Requirements

The *BC Energy Plan: A Vision for Clean Energy Leadership* (BC Ministry of Energy, Mines, and Petroleum Resources 2007) has set a goals to “eliminate all routine flaring at oil and gas producing wells and production facilities by 2016, with an interim goal to reduce routine flaring by 50% by 2011”.

The BC Oil and Gas Commission (OGC) *Flaring and Venting Reduction Guideline* provides regulatory requirements and guidance for flaring, incinerating, and venting in BC, as well as procedural information for their measurement. The guideline applies to well sites, facilities, and pipelines regulated under OGAA and focuses exclusively on requirements and processes associated with the BC OGC legislative authorities. This guideline has continued to evolve in order to achieve

the Energy Plan's goals. The major 2013 changes to the flaring regulatory program applicable to this Project include the requirement for flare meters at large compressor stations and the requirement to consider the use of incineration when flaring near populated areas.

Clean Energy Act

The *Clean Energy Act* (Government of British Columbia 2010) encourages development of BC's clean and renewable resources and promotes energy self-sufficiency, independent power production, and reductions in GHG emissions. It also provides a substantial revision of the governance framework for energy policy and the articulation of new and revised objectives for BC's energy policy. In July 2012, the Act was updated to exclude LNG export facilities, and the electricity generation used to power them, from the Act's 93% clean and renewable energy mix requirements (biomass, biogas, geothermal heat, hydro, solar, ocean, wind).

BC Natural Gas Strategy

On February 3, 2012, BC released its natural gas and complementary strategy focusing specifically on the emerging LNG sector. The LNG strategy supports proponents' LNG projects, including working to reduce historical barriers—whether regulatory, administrative or socio-economic—to construction and operation. In particular, the LNG strategy identifies specific actions such as coordinating permitting and approval processes among agencies and investing in critical infrastructure to power future LNG facilities in support of the development of the LNG sector. Specific actions for reducing GHG emissions from LNG facilities include, but are not limited to, reducing natural gas flaring using innovative solutions, implementing practices and emission reduction technologies, and promoting the use of carbon capture and storage in BC.

7.2.2 Influence of Consultation on the Assessment

Concerns regarding the Project's potential contribution to current GHG emissions were identified by Aboriginal groups, government departments (e.g., the Climate Action Secretariat), and the public. GHG management was included as a standalone section within the EIS/Application because of these concerns. An assessment of the potential effect of project GHG emissions on the overall BC and national emission reduction targets was requested during consultation.

7.2.3 Selection of Potential Effects

The potential effect of the Project is the increase in GHG emissions and the consequences to the provincial and national GHG reduction policies and targets.

In a typical assessment of project effects on the environment, potential effects are assessed by defining discrete criteria for the characterization of residual effects and determination of significance. As per the *Canadian Environmental Assessment Act*, 2003, potential effects of GHG emissions on the environment cannot be assessed meaningfully for a single project such as this Project. For this reason, the GHG management assessment focuses on quantifying project emissions and introducing engineering solutions that aim to reduce emissions and make this Project best-in-class.

7.2.4 Selection of Measurable Parameters

Sources of GHG emissions are natural and anthropogenic in origin. A GHG is any atmospheric gas that absorbs and re-emits infrared radiation, warming the lower levels of the atmosphere. The primary GHGs are:

- **Carbon dioxide** (CO_2)—CO_2 is released through natural processes such as volcanic eruptions and through human activities such as deforestation, land use changes, burning of fossil fuels, and oil and gas processing.
- **Methane** (CH_4)—CH_4 is a hydrocarbon gas produced through natural sources and is the main component of natural gas. It is also produced by human activities, including the decomposition of wastes in landfills, agriculture, and rice cultivation. CH_4 is a far more efficient GHG than CO_2 (higher global warming potential), but is much less abundant in the atmosphere.
- **Nitrous oxide** (N_2O)—N_2O is a powerful GHG produced by soil cultivation practices, especially with the use of commercial and organic fertilizers, fossil fuel combustion, nitric acid production, and biomass burning.
- **Sulfur Hexafluoride** (SF_6)—SF_6 is human-made, synthetic gas is denser than air and therefore remains close to the earth's surface. SF_6 is a particularly potent GHG and is very stable. In Canada, the major use of SF_6 is in industrial processes that use it as a cover gas or insulating gas.
- **Ozone** (O_3)—A component of smog in the lower atmosphere and a protective substance in the stratosphere that shields Earth from ultraviolet light, O_3 is also an important GHG. It is created in photochemical reactions between other pollutants such as oxides of nitrogen and volatile organic compounds in the presence of sunlight.
- **Hydrofluorocarbons** (HFCs)—HFCs are a series of synthetic gases that have large global warming potentials due to their long atmospheric lifetimes. The main sources of HFCs are refrigerant fluids in industrial processes or used as a cover gas in metal production.
- **Perfluorocarbons** (PFCs)—PFCs are a series of gases which were introduced as an alternative to ozone depleting substances. PFCs have a large global warming potential and are primarily used in the manufacturing industry.

In this assessment, GHG management considers project emissions in terms of CO_2, CH_4 and N_2O. Project activities will not contribute emissions of SF_6, O_3, H_2O, HFCs and PFCs. Although the Project may use SF_6 insulated switchgear (34.5 kV in the main substation), SF_6 will be contained in sealed vessels, eliminating any potential for fugitive emissions.

GHG management estimates usually incorporate emissions of CO_2, CH_4, and N_2O in units of CO_{2e}. CO_{2e} estimates are calculated by multiplying the emission rate of each substance by its global warming potential (GWP) relative to CO_2. The GWP of the three main GHGs are as follows: CO_2 = 1.0, CH_4 = 21, and N_2O = 310. Therefore, CO_{2e} is equal to ([CO_2 mass emissions x 1] + [CH_4 mass emissions x 21] + [N_2O mass emissions x 310]). Although the values for global warming potential have recently been updated by the IPCC, BC MOE has not updated its GWP values, so previous GWP ratings are used for this assessment. In an attempt to quantify the effect of project GHG emissions, project CO_{2e} estimates are compared to BC and national emissions estimates and targets.

7.2.5 Boundaries

7.2.5.1 Temporal Boundaries

Based on the current project schedule, the temporal boundaries for each phase are:

- **Construction:** Q1 2015– Q4 2018
- **Operations:** Q1 2019 – 2048+
- Decommissioning: 2048+

Site preparation will be completed in the first year and construction of Phase 1 (Train 1 and Train 2) will require up to four years. The first shipment of LNG is planned for early 2019. Phase 2 (Train 3) will be constructed starting in 2019, pending favorable market conditions.

7.2.5.2 Spatial Boundaries

Spatial boundaries for the assessment are defined by government jurisdictional policies. The assessment compares project-related GHG emissions to BC and Canada GHG emission totals. Project emissions are also discussed in the global context.

7.2.5.3 Administrative and Technical Boundaries

Administrative boundaries relevant to greenhouse gas management are those related to emission reduction targets. These include the borders of BC and Canada. Technical boundaries include the accuracy of datasets used as inputs to the models used in the assessment.

7.3 Baseline Conditions

7.3.1 Provincial and National GHG Emissions Inventory

Provincial and national total GHG estimates are available from the BC GHG Inventory and the EC National Inventory Report (NIR) (Table 7-1). GHG emissions are reported in units of tonnes of carbon dioxide equivalents per year (t CO_{2e}/y) starting in 1990. The BC annual estimates are consistently higher than the EC estimates for the same province. The discrepancy between the two is the result of the different approaches applied in each inventory. The BC inventory uses locally collected and reported GHG data (bottom up approach), whereas the national inventory determines estimates by using industry averages and segregating emissions into specific sectors, provinces and territories without relying on data from individual emitters (top down approach).

Based on latest EC data, Canada emitted about 702 million tonnes (Mt) of CO_{2e} in 2011, of which 8.4% is from BC (59.1 Mt CO_{2e}). The overall national oil and gas sector emissions were 11 Mt CO_{2e} in both 2010 and 2011.

The most recent BC GHG inventory (BC MOE 2013) reported 62.2 Mt CO_{2e} for the same year (2011). Most emissions are from transportation-type activities (23 Mt CO_{2e}) and combustion sources (19 Mt CO_{2e}).

For comparison purposes, Table 7-1 includes the projected provincial and national targets for 2020. To meet the BC provincial reduction target of 33% (Government of British Columbia 2008b), in 2020 the total provincial GHG inventory will need to be about 43 Mt CO_{2e} in reference to the 2007 levels

reported by BC. Similarly, if Canada's voluntary Copenhagen reduction target of 17% is applied (EC 2010) to EC's 2005 levels, the total GHG inventory will need to be about 612 Mt CO_{2e} nationally and 53 Mt CO_{2e} provincially by 2020.

Table 7-1: BC and National Greenhouse Gas Emissions Estimates (1990-2011)

Year	BC GHG Inventory Report[1,2]	EC National GHG Inventory Report[3]	
	BC Total (t CO_{2e}/y)	BC Total (t CO_{2e}/y)	Canada Total (t CO_{2e}/y)
1990	55,518,000	49,400,000	591,000,000
2000	65,754,000	61,900,000	718,000,000
2005	65,554,000	64,000,000	737,000,000
2010	61,993,000	59,900,000	701,000,000
2011	62,213,000	59,100,000	702,000,000
Applicable Reduction Targets			
2020	43,480,000*	53,120,000*	612,000,000**

SOURCES:
[1] BC MOE. 2012. BC GHG Inventory Report 2010.
[2] BC MOE. 2013. Summary of BC GHG Emissions 2011.
[3] EC. 2013. National Inventory Report 1990 to 2011.

NOTES:
* *The Greenhouse Gas Reduction Targets Act* of BC has set the 2020 provincial target at 33% below 2007 levels.
** Canada's voluntary Copenhagen target for 2020 is set at 17% below the 2005 level.

7.3.2 Industry Profile

In order to assess the effect of project GHG emissions, CEAA recommends comparing project specifics with a representative industry profile (CEAA 2003). In this way, the proponent can assess the effectiveness of its engineering design measures to achieve and exceed the latest industry and jurisdictional standards. In Canada, the LNG-specific industry is in its infancy, with both provincial and national jurisdictions working proactively to establish clear, robust guidelines and policies that encourage emissions reductions for newly proposed projects. National exposure to existing LNG-type activities is limited to the first and only Canadian LNG import terminal (Canaport LNG) located in Saint John, New Brunswick. The US market is predominantly an LNG importer (from Trinidad and Canadian markets), with one intermittently operational LNG export terminal in Kenai, Alaska.

Although a number of export LNG terminals exist worldwide, establishing an industry profile based on this data does not provide a reasonable benchmark for the industry. Projects that are currently operating reflect various regulatory requirements, many of which may have since changed. In addition, best achievable technology considered suitable at the time of installation has transformed over the last two decades. Recent LNG-specific advancements have focused on reducing air emissions from both the principle machinery (e.g., gas turbines) and the process design (e.g., waste heat recovery, refrigerant selection). In this context, the industry profile provides the most appropriate benchmark for this Project should be limited to estimates of emissions associated with LNG projects that are under development or have been recently proposed.

Figure 7-1 compares the carbon footprint of twelve LNG export facilities proposed worldwide. Project-specific GHG emissions are in units of GHG intensities, as a ratio of tonnes of CO_{2e} per tonne of LNG produced (t CO_{2e}/t LNG).

Comparison of the GHG intensity of one project to another is not straightforward. The data presented in Figure 7-1 comes from a range of sources (i.e., environmental assessments, public announcements). For this reason, it is important to recognize that the methods used to calculate GHG emissions are not standardized, but are the best publically disclosed data available to date. In addition, each of these projects relies on engineering designs unique to the project and site. Even though these variations exist, the available data does provide a reasonable profile of the latest advancements in the LNG export industry. The average GHG intensity for the proposed projects is 0.33 t CO_{2e}/t LNG. Among projects that are proposed or under development, the Queensland Curtis (QC) LNG Project is designed to have the lowest GHG intensity of about 0.25 t CO_{2e}/t LNG, forming the basis for the LNG export industry profile used in this assessment.

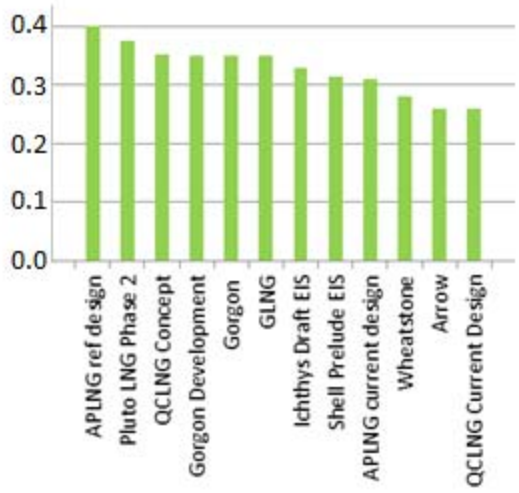

Figure 7-1: GHG Intensity (t CO_{2e}/t LNG) for Proposed Export LNG Projects

7.4 Project Activities Resulting in Greenhouse Gas Emissions

The Project will contribute to the provincial and national GHG emission totals by emitting GHGs through combustion of fossil fuels during all phases of the Project. Project activities that specifically emit GHGs are listed in Table 7-2.

During construction, power delivery may include on-site diesel-powered electrical power generators. If diesel power generators are required the equipment will use ultra-low sulfur diesel, and the overall air emissions are expected to be negligible and of short duration.

Table 7-2: Potential Effects on Existing Greenhouse Gas Emissions

Project Activities and Physical Works	Potential Effects on Existing GHG Emission Levels
Construction	
Site preparation (land-based)	Site clearing will reduce the carbon sink on Lelu Island by removing trees and peat bog. Recovered merchantable timber will be sold, reducing the amount of refuse burned on site.
Onshore construction Vehicle traffic Dredging Marine construction	Combustion of fossil fuels by land-based and marine-based heavy duty equipment will generate GHG emissions.
Operations	
Operation of LNG Facility and supporting infrastructure on Lelu Island	Under normal operations, the Project will use natural gas to drive refrigerant compressors and power generators producing GHG emissions. Smaller amounts of GHG emissions will result in fugitive emissions originating from piping, valve and other connections.
Marine terminal use Shipping	Combustion of fossil fuels by marine-based equipment (LNG carriers and tug boats) will generate GHG emissions.

7.5 Effects Assessment

7.5.1 Construction

7.5.1.1 Site Preparation

Site preparation will require clearing and grading of 160 ha of land on Lelu Island. This activity is expected to take about 6 months. The site currently consists of bog wetland and forest. Vegetation removal will be avoided within 30 m of the high water mark to maintain the ecological function of the riparian area and the heritage value of many of the culturally modified trees present on Lelu Island. These deforestation activities will generate GHGs (i.e., burning cleared vegetation).

The BC Ministry of Forests, Lands and Natural Resource Operations conservatively estimates that 526 tonnes CO_{2e} per hectare (ha) will be liberated by deforestation of any particular site on the Northwest Coast Region (Dymond 2013). GHG emissions are directly associated with the removal and transfer of merchantable wood from the site to the forest products sector. Deforestation of the 160 ha project site will release 84,160 tonnes of CO_{2e}. Where possible, merchantable timber and culturally modified trees will be removed from the site and offered to local First Nations or local enterprises.

The net difference between the removal of a carbon sink and subsequent site reclamation to its original state is insubstantial in the long term. For this reason, the temporary decrease in the carbon sink potential resulting from deforestation of Lelu Island is not considered further.

7.5.1.2 Construction Activities

The primary sources of GHG emissions will be exhaust from diesel combustion by heavy land-based and marine equipment used during site preparation, onshore construction, vehicle traffic, dredging, and marine construction. Generally, construction GHG emissions are proportional to the disturbed

land area and the level of construction activity. They are limited to periods of day and week when the construction activities are schedule. Detailed assumptions (e.g., power rating, emission factors) used to calculate the GHG emissions inventory are provided in the Air Quality TDR (Appendix C).

Construction of the first two trains is expected to take up to five years. Year 1 of construction will focus on establishing bridge and road access, site preparation, and the construction of the MOF. Subsequent years (Year 2 to Year 5) will focus on Phase 1 construction, including the facility installation (Train 1 and Train 2), dredging and installation of the LNG trestle. Phase 2 (Train 3 installation) will be scheduled pending favourable market conditions; GHG emissions from Phase 2 construction activities will be much less than the emissions from Phase 1.

Predicted GHG emissions are summarized in Table 7-3 in units of tonnes per year (t/y). The majority of GHG emissions are expected to occur during the first year of construction when site preparation is ongoing. The total GHG emissions are estimated at about 0.18 Mt CO_{2e} for the full period of construction.

Table 7-3: Estimated GHG Emissions from Site Clearing and Project Construction

Activity Type	GHG Emissions (t/y)			
	CO_2	CH_4	N_2O	CO_{2e}
Year 1 – Bridge and road access, site preparation, MOF construction				
Site clearing	-	-	-	85,738
Land-based	15,295	0.82	5.85	15,447
Marine-based	2,553	0.25	0.51	2,556
Total GHG Emissions (Year 1)	**17,848**	**1.07**	**6.36**	**103,741**
Years 2-5 – Facility installation, dredging, marine construction				
Land-based	14,065	0.78	5.74	14,198
Marine-based	4,401	0.46	0.73	4,409
Total GHG Emissions (Years 2-5)	**18,466**	**1.24**	**6.47**	**18,607**
Total Construction Phase (Year 1-5)				**178,169**

7.5.2 Operation

The facility will consist of the following components—raw gas reception, gas pre-treatment, liquefaction, utility, off-site jetty-trestle, product storage/loading and infrastructure facilities. At full build-out, the Project will receive approximately 3.2 billion standard cubic feet per day of pipeline grade natural gas and produce up to 19.2 million tonnes per annum (MTPA) of liquefied natural gas (LNG). The Project will be constructed in two phases with the first phase having a design capacity of 12.8 MTPA of LNG with an additional 6.4 MTPA of capacity to be developed as market demand requires.

As a conservative approach, this assessment quantifies project GHG emissions at full operational build-out (3 Trains). The Project will rely on nine natural gas 26.8 MW turbines (three on standby) to supply processing power. Each liquefaction train will consist of an identical set of continuous emission sources: two 85.4 MW compressor mechanical drivers, and one thermal oxidizer per train. The compressor turbines will provide power for the compression function only. The generator

turbines will provide power for the entire facility. Turbine selection will be in accordance with BC MOE best achievable technology (BAT) policy for controlling air emissions (BC MOE 2012).

By adopting a zero flaring philosophy, the shared flare stacks will generate minimal emissions during normal operations from the continuously ignited pilot light. Flare stack operations will only be used for reliable and safe disposal of hydrocarbon streams in upset operating conditions and emergencies.

GHG emissions will be produced by LNG carrier vessels and assist tugboats used to manoeuver the vessels to and from the marine wharf. At full build-out operations, a total of 350 LNG carriers will be expected to berth every year, with a capacity up to 217,000 m^3 or 106,897 deadweight tonnes (DWT). A total of four tug boats will be dedicated to the Project.

A summary of the total project land and marine emissions at full build-out are provided in Table 7-4. The total project GHG emissions are 5.28 Mt CO_{2e}/y. The majority of emissions are attributed combustion of natural gas by the compressor drivers, with smaller contributions from common utilities (e.g., flares, power generation, LNG carriers and tugs).

Table 7-4: Estimated GHG Emissions during Operations

Operation Type	GHG Emissions (t/y)			
	CO_2	CH_4	N_2O	CO_{2e}
3 LNG Trains (two compressors and one oxidizer per train)	4,158,973	293	279	4,251,498
Gas turbine power generation	951,078	74	71	974,737
Flares	7,077	1	0	7,148
Total Land-Based Emissions	**5,117,127**	**368**	**350**	**5,233,383**
Total Marine-Based Emissions	**47,559**	**3**	**2**	**48,266**
Total GHG Emissions	**5,164,687**	**371**	**352**	**5,281,649**

At peak capacity of 19.2 MTPA, the project GHG intensity will be a ratio of 0.27 t CO_{2e}/t LNG. The intensity is a function of land-based combustion GHGs emissions. Marine activities (LNG carriers and tug boats) do not quantify under the BC reporting requirements. This value is below the industrial average of 0.33 t CO_{2e}/t LNG (see Section 7.3.2) and very close to the best of all projects considered.

The project GHG intensity ratio reflects the maximum worst-case emissions at full build out. Actual GHG emissions during normal operations are expected to be lower because the Project will be designed to include engineering solutions that reduce emissions and make this Project best in class (less than 0.25 t CO_{2e}/t LNG). In addition, the project intensity of 0.27 t CO_{2e}/t LNG assumes sources of emissions are operating at 100% load, but the load factor during normal operations will likely be lower, and hence, the GHG intensity during normal operations is expected to be further reduced. To achieve this goal, final engineering philosophy will reduce GHG emissions by selecting technology and best management practices which comply with the BC BAT Policy.

7.6 Effects on GHG Reduction Targets

At full build-out, the Project will release about 5.28 Mt CO_{2e}/year to the environment. This will increase the BC (62.2 Mt CO_{2e}/y) and national (702 Mt CO_{2e}/y) emission totals by 8.5% and 0.75%,

respectively, based on 2011 levels (see Section 7.3.1). This is a substantial increase in regards to BC's prevailing GHG reduction commitments. Increases in GHG emissions from projects with similar emission profiles (greater than 1 Mt CO_{2e}/y) will challenge BC's commitment to the 2020 cumulative target of 43.5 Mt CO_{2e} based on 2007 levels (see Section 7.3.1). To date, clear guidance on how Canada and BC will address this issue has not been communicated. This Project will continue to work closely with applicable jurisdictions. In the interim, reductions in GHG emissions will be encouraged by selecting innovating technology. The implementation of best GHG management practices throughout project operation will assist in further reducing the effect of GHG emissions.

Natural gas is one of the cleanest burning fossil fuels. At a global scale, it is likely that the consumption of market LNG will displace the use of higher carbon fuels (such as oil and coal) used elsewhere. By replacing higher carbon fuels with LNG, consumption of LNG as fuel will likely have a positive global effect and reduce the global GHG emissions. Such GHG reduction benefits could be considerable, since fuels such as oil or coal can emit up to 22% to 45%, respectively, more GHG per unit of energy than natural gas. Further, the use of natural gas in transportation instead of gasoline or diesel can reduce CO_{2e} emissions by 15% to 25% for an equivalent amount of energy.

In the context of CEAA (2003) and IPCC (2013), a significant residual effect would cause a substantial material change in total global GHG emissions. Global emissions in 2012 were determined at 34,500 Mt CO_{2e}/y (PBLNEAA 2013). The Project's GHG emissions would contribute 0.015% to the global values. This contribution would cause a small material change to the total global GHG emissions. In this context, the potential environmental global effects of this one Project are not significant.

7.7 GHG Management Options

Best GHG management options considered by PNW LNG include development of the GHG management plan, adapting best site clearing practices, and incorporating the BC BAT policy as part of best-in-class final design for the Project. These options are considered even while significant political and legislative uncertainty remains. To date, the BC and national governments have not implemented clear GHG regulations for the up and coming LNG export industry. PNW LNG recognizes that the GHG Management Plan (see Section 24) may evolve with changing policies and best practices.

7.7.1 GHG Management Plan

PNW LNG recognizes the challenges posed by emissions of GHGs and intends to develop a facility-specific emissions management plan as part of its integrated health, safety and environmental management system. The plan will address regulatory developments by preparing compliance plans, implementing new business processes and emerging regulatory requirements into project operations. The plan will cover aspects such as:

- Commitment to reducing the project GHG intensity through final project design
- Compliance with relevant GHG emissions management and reporting legislations
- Reduction of fugitive emissions by implementing a proactive Directed Inspection and Maintenance (DIM) and Leak Detection and Repair (LDAR) program
- Adherence to existing venting and flaring reduction requirements.

Because it is expected that emissions from this Project will exceed 50,000 t CO_{2e}/y, the Project will report emissions to the BC MOE (10,000 t CO_{2e} threshold) by March 31 for the preceding year of operations, and will also have the report verified by an accredited third party by March 31 (25,000 t CO_{2e} threshold). The annual emissions will also be reported to EC as required by June 1 following each reporting year (50,000 t CO_{2e}/y threshold).

PNW LNG will develop and implement a facility specific Fugitive Emission Management Program (FEMP) in accordance with the permit requirements. The FEMP will meet or improve upon the Canadian Association of Petroleum Producers (CAPP) Best Management Practice for Fugitive Emissions Management. The FEMP will help PNW LNG manage its fugitive emissions, BC facility inspection, and GHG measurements in a cost-effective manner. Fugitive leak detection will be achieved by completing regular facility-wide surveys, inspecting facility components daily, and deploying the gas detection monitoring system as part of normal operational activities.

7.7.2 Land Clearing and Biomass Burning

Construction deforestation activities will generate GHGs (i.e., burning cleared vegetation) and decrease the carbon sink potential of the natural ecosystem in the short-term. To reduce the GHG emissions related to deforestation, disturbed overburden soils will be re-vegetated to a stable and maintenance-free status where the original condition can be continued. Also, the vegetative buffer will be retained around the island.

7.7.3 Designing the Best-in-Class LNG Facility

PNW LNG strives to identify the best and most optimal solutions using criteria such as supply reliability, operational and capital costs and system characteristics, expected equipment utilisation rates, and influence on GHG emissions and fuel efficiency. Selection of suitable state of the art technology will focus on reducing emissions on three fronts: main machinery selection, process design, and fugitive emissions. For example, the Project will use high efficiency aero-derivative gas turbines that need less fuel and generate less GHG emissions in comparison to industrial gas turbines, motor drives and steam turbines used by existing LNG export terminals. The Project is also focused on reducing energy consumption by applying state-of-the-art waste heat recovery systems. To reduce fugitive GHG emissions, the Project will also maximize use of welded joints instead of flanged connections in all components not requiring maintenance. PNW LNG will incorporate a combination of proven and innovative engineering solutions to build a facility that is best in class (see Section 7.3.2).

The Project will apply green building principles by selecting energy efficiency materials and systems that meet the Leadership in Energy and Environmental Design (LEED) pillars. Buildings in non-manufacturing areas will implement LEED principles in their design as part of sustainable development efforts. Although an official LEED certificate will not be sought for the project site, the LEED principles of designing and building a green building will be encouraged.

PNW LNG will continue to evaluate energy saving and GHG reduction options for inclusion in future expansions (Phase 2/Train 3) or potential to employ in the initial phase of construction (for example, LED lighting). LED lighting is new to the market for hazardous locations and is being reviewed for use at the Project and will be included if found to be economically viable and technically acceptable.

Overall, PNW LNG's goal is to incorporate the reduction of GHG emissions by adapting solutions that meet the BC BAT policy.

7.7.4 Reduction in Methane Emissions

BC regulations allow venting of gas to atmosphere during maintenance or capital project work if there are no economic means to capture vented gas. PNW LNG will use various alternatives to limit venting of GHGs in order to reduce emissions and conserve gas. These alternatives include, but are not limited, to converting boil-off gas to LNG and, if upset conditions required venting, flaring methane to convert it to CO_2 (lower GWP).

7.8 Follow-up and Monitoring

PNW LNG will comply with provincial and national GHG emission reporting requirements, which will include third party verification of emissions accounting.

7.8.1 Reporting Requirements

Annual GHG emissions will be reported to the BC MOE and Environment Canada as required.

7.9 Conclusion

There is a consensus within the scientific community that GHG emissions are altering global climate, but that the effect is due to the multitude of emissions sources and is not related to an individual activity or project (CEAA 2003, IPCC 2013). GHG emissions from the Project are expected to represent a small fraction of global GHG emissions:

- Project construction GHG emissions are estimated to amount to 0.18 Mt CO_{2e} over the five years.
- Project operations GHG emissions are estimated to amount to 5.28 Mt CO_{2e} per year.
- Based on the 2011 provincial and national GHG baselines, the Project's annual GHG emissions will increase the emission totals by 8.5% provincially and 0.75% nationally.
- Based on data from 2008 to 2012 (BC MOE 2012, EC 2013), the Project's annual GHG emissions will increase the global GHG emission totals by 0.015%.

The majority of project GHG emissions will originate from the combustion of fuel, that will be subject to the BC carbon tax. By placing a price on carbon, PNW LNG is able to internalize the cost of releasing GHG emissions. This may lead to deployment of GHG reduction measures that are currently not employed by existing LNG export terminals. Upon EIS/Application approval, PNW LNG will develop a facility-specific Greenhouse Gas Management Plan. The plan will meet and anticipate regulatory developments by preparing compliance plans, implementing business processes and taking mitigation action to manage the costs and influence of emerging GHG BC and national regulatory requirements.

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